

### **REMARKS**

This Preliminary Amendment cancels, without prejudice, claims 1 to 25 in the underlying PCT Application No. PCT/EP2004/010550 and adds new claims 26 to 52. The new claims, inter alia, conform the claims to United States Patent and Trademark Office rules and does not add any new matter to the application.

In accordance with 37 C.F.R. § 1.125(b), the Substitute Specification (including the Abstract) contains no new matter. The amendments reflected in the Substitute Specification (including Abstract) are to conform the Specification and Abstract to United States Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. §§ 1.121(b)(3)(ii) and 1.125(c), a Marked-Up Version of the Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. Approval and entry of the Substitute Specification (including Abstract) are respectfully requested.

The underlying PCT Application No. PCT/EP2004/010550 includes an International Search Report, dated December 16, 2004, a copy of which is included. The Search Report includes a list of documents that were considered by the Examiner in the underlying PCT application.

The underlying PCT Application No. PCT/EP2004/010550 also includes an International Preliminary Examination Report, dated December 13, 2005. An English translation of the International Preliminary Examination Report is included herewith.

It is respectfully submitted that the subject matter of the present application is new, non-obvious and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully submitted,

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By: \_\_\_\_\_



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## MEASURING DEVICE FOR A MOTOR VEHICLE

## Description

**FIELD OF THE INVENTION**

The present invention relates to a measuring device, ~~in particular.~~ For example, the present invention relates to a  
5 position measuring device, e.g., a measuring device for a motor vehicle, for measuring a distance between the measuring device and at least one object and/or for measuring a speed difference between the measuring device and the at least one object, the measuring device having an emitting device for  
10 sending a transmission signal, which includes at least two signal portion sequences, a first signal portion sequence and a second signal portion sequence, having each at least two temporally alternating signal portions, the at least two signal portions of a signal portion sequence differing in  
15 their frequency in each case by one differential frequency.

**BACKGROUND INFORMATION**

~~Such a~~ A measuring device developed as a radar device is ~~known from DE~~ described in German Published Patent Application No.  
20 100 50 278 [[A1]] or from the dissertation by M.-M. Meinecke "Regarding Optimized Transmission Signal Design for Automobile Radars", Technical University Hamburg-Harburg, 2001. ~~Thus DE~~  
German Published Patent Application No. 100 50 278 [[A1]]  
~~discloses~~ describes the determination of a distance and of a  
25 relative speed of at least one distant object from an observation point with the aid of electromagnetic signals emitted from the observation point in the form of alternately emitted signal portions of a first frequency and of a second frequency, which following a reflection by the object are  
30 received and evaluated, the signal portions of the two frequencies being emitted during a measuring interval such

that they are shifted in each case by one constant frequency increment.

The use of a radar device in the automotive sector is also  
5 ~~known from~~ described in the dissertation "Radar Systems for  
the Automatic Distance Control in Automobiles" by R. Mende,  
Technical University Carolo-Wilhelmina, Braunschweig, 1999, as  
well as ~~from DE~~ German Published Patent Application No.  
199 22 411 [[A1]], [[DE]] German Published Patent Application  
10 No. 42 44 608 [[C2]] and [[DE]] German Published Patent  
Application No. 100 25 844 [[A1]].

[[DE]] German Published Patent Application No. 199 22 411  
[[A1]] discloses describes a CW radar method (continues wave  
15 radar method) for measuring distances and relative speeds  
between a vehicle and one or several obstacles, in which a  
transmission signal is made up of at least four consecutive  
blocks having in each case different gradients. In a  
distance-relative speed diagram, first the intersections of  
20 all straight lines from two blocks of all discovered frequency  
positions are calculated. For validating these intersections,  
they are checked as to whether in the Fourier spectrum of a  
third block there exists a peak at a frequency position, whose  
associated straight line in the distance-relative speed  
25 diagram intersects a surrounding region of the intersection.  
The intersections validated in this manner are subjected to a  
second condition, whether in the Fourier spectrum of a fourth  
block there exists a peak at a frequency position, whose  
associated straight line in the distance-relative speed  
30 diagram intersects a surrounding region of the intersection.  
The intersections are regarded as valid if they satisfy both  
conditions.

[[DE]] German Published Patent Application No. 42 44 608  
35 [[C2]] discloses describes a radar method for measuring

distances and relative speeds between a vehicle and obstacles in front of it, comprising an emission of continuous transmission signals, simultaneous reception of signals reflected by the obstacles during the emission of the  
5 continuous transmission signals, mixing of the reflected signals with the continuous transmission signals for obtaining inphase and quadrature signals and processing of these signals into output signals for the distances and relative speeds of the obstacles, the continuous transmission signals being  
10 broken down into constant frequency increments of constant time duration without time interval with respect to each other and at each constant frequency increment of the reflected received signal a complex sampling value being recorded and mixed with the transmission signal of the same constant  
15 frequency increment.

[[DE]] German Published Patent Application No. 100 25 844  
[[A1]] ~~discloses~~ describes an incrementally linear frequency-modulated transmission signal, at least two incrementally  
20 linear frequency-modulated ramps being mutually interwoven. Characteristic in this regard is the fact that these two or more ramps have a constant frequency shift with respect to one another. By frequency measurement and phase difference measurement it is possible to calculate unambiguously the  
25 distance of the object and the speed of the object from the received signals.

In addition it is ~~known from DE~~ describe in German Published Patent Application No. 43 31 440 [[A1]] to form for the radar  
30 device I/Q signal pairs for the signal evaluation, a phase shifter being connected between a radar antenna and a radar front end, an evaluation circuit having two signal channels on the input side, the radar front end being connectable via a channel switch to one of the two signal channels, the phase  
35 shifter and the channel switch being clocked synchronously and

the phase shifter switching the phase between 0° and 45° with each clock cycle.

A Doppler radar device for a vehicle for indicating a distance between the vehicle and an obstacle is ~~known from DE~~ **described in German Published Patent Application No. 689 13 423 [[T2]]**.

#### **SUMMARY**

~~It is the objective~~ **Example embodiments** of the present

~~invention to indicate~~ **may provide** a measuring device having an improved measuring accuracy, **e.g.**, as compared to [[DE]] **that described in German Published Patent Application No.**

100 50 278 [[A1]]. For this purpose it ~~is desirable~~ **may be possible**, with the aid of the measuring device, to keep the occurrence of so-called ghost targets low or to eliminate it entirely, to allow for a measuring time of less than 10ms and to allow for the detection of objects at a very close range (0m ... 1m) as well as at a medium and remote range.

~~The above mentioned objective is achieved by~~ **According to example embodiments of the present invention** a measuring device, ~~in particular~~ **e.g.**, a measuring device for a motor vehicle, **is** for measuring a distance between the measuring device and at least one object and/or for measuring a speed difference between the measuring device and the at least one object, the measuring device ~~having~~ **including** an emitting device for sending a transmission signal, which includes at least two signal portion sequences, a first signal portion sequence and a second signal portion sequence, having each at least two temporally alternating signal portions, at least two signal portions of a signal portion sequence differing in their frequency in each case by one differential frequency, the differential frequency of the first signal portion sequence differing from the differential frequency of the

second signal portion sequence, ~~in particular~~ e.g., by at least 5%, advantageously e.g., by at least 10%.

~~In an advantageous refinement of the present invention, the~~  
5 The measuring device ~~has~~ may include a receiving device for receiving a reflection signal of the transmission signal reflected by the at least one object and advantageously, e.g., a mixer for mixing the first signal portion sequence with a portion of the first signal portion sequence reflected by the  
10 at least one object to form a first mixed signal. ~~In a further advantageous refinement of the present invention, the~~  
The measuring device may additionally ~~has~~ include an evaluation device for ascertaining the frequency or frequencies of the first mixed signal. The evaluation may  
15 occur with the aid of an FFT (fast Fourier transform), for example.

~~In another advantageous refinement of the present invention, the~~  
20 The evaluation device ~~allows~~ may allow for the distance between the measuring device and the at least one object and/or the speed difference between the measuring device and the at least one object to be determined as a function of the measured frequencies of the first mixed signal.

25 ~~In another advantageous refinement of the present invention, the~~  
The mixer ~~allows~~ may allow for the second signal portion sequence to be mixed with a portion of the second signal portion sequence reflected by the at least one object to form a second mixed signal, and the evaluation device ~~allows~~ may  
30 allow for the measured frequencies of the second mixed signal to be ascertained.

~~In another advantageous refinement of the present invention, the~~  
35 The evaluation device ~~allows~~ may allow for the distance between the measuring device and the at least one object

and/or the speed difference between the measuring device and the at least one object to be determined as a function of the measured frequencies of the first mixed signal and of the measured frequencies of the second mixed signal.

5

~~In another advantageous refinement of the present invention,~~  
the **The** evaluation device ~~allows~~ may allow for the difference between the absolute phase of the first mixed signal and the absolute phase of the second mixed signal to be determined.

10

~~In another advantageous refinement of the present invention,~~  
the **The** evaluation device ~~allows~~ may allow for the distance between the measuring device and the at least one object and/or the speed difference between the measuring device and  
15 the at least one object to be determined as a function of the difference between the phase of the first mixed signal and the phase of the second mixed signal.

~~In another advantageous refinement of the present invention,~~  
20 the **The** emitting device and the receiving device are may each include an antenna. The emitting device and the receiving device, however, may also be implemented by a common antenna.

~~In another advantageous refinement of the present invention,~~  
25 the **The** emitting device ~~[[is]]~~ may include an optical element, in particular e.g., a laser. ~~In another advantageous refinement of the present invention,~~ the **The** receiving device ~~in this instance is~~ may include a light-sensitive element, in particular e.g., a photoelement or a photodiode, which ~~[[is]]~~  
30 may be suited for measuring the phase of the reflected laser light.

~~The above mentioned objective is furthermore achieved by~~  
According to example embodiments of the present invention, a  
35 method is for measuring a distance between an emitting device

and at least one object and/or for measuring a speed difference between the emitting device and the at least one object, a transmission signal having at least two signal portion sequences, a first signal portion sequence and a second signal portion sequence, having each at least two temporally alternating signal portions being sent by the emitting device, at least two signal portions of a signal portion sequence differing in their frequency in each case by a non-constant differential frequency. The differential frequency of the first signal portion sequence may differ from the differential frequency of the second signal portion sequence, ~~in particular~~ e.g., by at least 5%, ~~advantageously~~ e.g., by at least 10%.

~~In another advantageous refinement of the present invention, a~~  
A reflection signal of the transmission signal reflected by the at least one object ~~[[is]]~~ may be received, ~~advantageously~~ e.g., the first signal portion sequence ~~[[is]]~~ may be mixed with a portion of the first signal portion sequence reflected by the at least one object to form a first mixed signal, and ~~advantageously~~ e.g., the dominating (measured) frequencies of the first mixed signal ~~[[are]]~~ may be ascertained.

~~In another advantageous refinement of the present invention,~~  
the The distance between the emitting device and the at least one object and/or the speed difference between the emitting device and the at least one object ~~[[is]]~~ may be determined as a function of the dominating frequencies of the first mixed signal.

~~In another advantageous refinement of the present invention,~~  
the The second signal portion sequence ~~[[is]]~~ may be mixed with a portion of the second signal portion sequence reflected by the at least one object to form a second mixed signal, and  
~~in another advantageous refinement of the present invention,~~



the dominating frequencies of the second mixed signal ~~[[are]]~~  
may be ascertained.

~~In another advantageous refinement of the present invention,~~  
5 the ~~The~~ distance between the emitting device and the at least  
one object and/or the speed difference between the emitting  
device and the at least one object ~~[[is]]~~ may be determined as  
a function of the dominating frequencies of the first mixed  
signal and of the dominating frequencies of the second mixed  
10 signal.

~~In another advantageous refinement of the present invention,~~  
the ~~The~~ difference between the phase of the first mixed signal  
and the phase of the second mixed signal ~~[[is]]~~ may be  
15 determined, and ~~in another advantageous refinement of the~~  
~~present invention,~~ the distance between the emitting device  
and the at least one object and/or the speed difference  
between the emitting device and the at least one object ~~[[is]]~~  
may be determined as a function of the differences between the  
20 phases of the first mixed signal and the phases of the second  
mixed signal.

A motor vehicle in ~~the sense of the present invention is in~~  
~~particular~~ context may include a land vehicle that may be used  
25 individually in road traffic. ~~In particular~~ However, motor  
vehicles in ~~the sense of the present invention are~~ context  
should not be considered to be restricted to land vehicles  
having an internal combustion engine.

30 Further advantages aspects and details are ~~derived from the~~  
~~following description of exemplary embodiments. The figures~~  
~~show:~~ of example embodiments of the present invention are  
described in more detail below with reference to the appended  
Figures.

35

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a front view of a motor vehicle[[]].

Fig. 2 is a side view of a motor vehicle[[]].

5

Fig. 3 illustrates an exemplary embodiment of a radar device[[]].

Fig. 4 illustrates an exemplary embodiment of a frequency-time diagram and.

10

Fig. 5 illustrates an exemplary embodiment of an optical measuring device.

## 15 DETAILED DESCRIPTION

Fig. 1 and Fig. 2 ~~show~~ illustrate a motor vehicle 1 in an exemplary embodiment. Fig. 1 ~~shows~~ is a front view of motor vehicle 1, and Fig. 2 ~~shows~~ is a side view of motor vehicle 1. Motor vehicle 1 has a front bumper 2 and a rear bumper 3. In the exemplary embodiment illustrated, front bumper 2 has distance and/or speed sensors 10, 11, 12, 13, 14, 15, 16 for measuring a distance R between motor vehicle 1 and at least one object or obstacle 20 such as another motor vehicle, for example, and/or for measuring a speed difference v between motor vehicle 1 and the at least one object or obstacle 20, speed difference v being the difference between the speed vH of obstacle 20 and the speed vF of motor vehicle 1.

20

25

Depending on the application of distance and/or speed sensors 10, 11, 12, 13, 14, 15, 16, more or fewer distance and/or speed sensors may be ~~situated~~ arranged on bumper 2. This means that it is also possible that only one sensor is used. Alternatively or additionally, distance and/or speed sensors may also be ~~situated~~ arranged on rear bumper 3, on side

30

mirrors 4, 5, on side doors 6, 7, on A, B, C pillars and/or on

35

a hatchback 8, etc. The distance and/or speed sensors may be oriented in different directions and/or at different levels. Examples of the application of such distance and/or speed sensors ~~can be gathered from the dissertation~~ are described in

5 "Radar Systems for the Automatic Distance Control in Automobiles" by R. Mende, Technical University Carolo-Wilhelmina, Braunschweig, 1999.

Fig. 3 ~~shows~~ illustrates a radar device 30, which is usable as  
10 a distance and/or speed sensor 10, 11, 12, 13, 14, 15, 16, for example. Radar device 30 has a radar sensor 40 and an evaluation device 41. Radar device 30 has an oscillator or a signal generator 31 for producing a transmission signal  $s(t)$ , a transmitting antenna 35 for emitting the transmission signal  
15  $s(t)$  and a receiving antenna 36 for receiving a reflection signal  $r(t)$  of the emitted transmission signal  $s(t)$  reflected by an object such as obstacle 20.  $t$  indicates time in this context.

20 Transmission signal  $s(t)$  produced by signal generator 31 includes at least two signal portion sequences, a first signal portion sequence and a second signal portion sequence, having each at least two temporally alternating signal portions, the at least two signal portions of a signal portion sequence  
25 differing in their frequency in each case by one differential frequency, and the differential frequency of the first signal portion sequence differing from the differential frequency of the second signal portion sequence, ~~in particular~~ e.g., by at least 5%, ~~advantageously~~ e.g., by at least 10%. An exemplary  
30 embodiment of such a transmission signal is ~~shown~~ illustrated in Fig. 4 in a frequency-time diagram.

In this context, A1, A2, A3, ... indicate the signal portions of a first signal portion sequence A(t) and B1, B2, B3, ...  
35 indicate the signal portions of a second signal portion

sequence  $B(t)$ . Such signal portions are also called chirps. In the present exemplary embodiment, the time durations  $T_{\text{Burst}}$  for signal portions  $A_1, A_2, A_3, \dots$  and  $B_1, B_2, B_3, \dots$  are of equal length. Time duration  $T_{\text{Burst}}$  of signal portions  $A_1, A_2, A_3, \dots$  is ~~represented~~ illustrated in Fig. 4 by a solid line and time duration  $T_{\text{Burst}}$  of signal portions  $B_1, B_2, B_3, \dots$  is ~~represented~~ illustrated by a dashed line.

The frequency within a signal portion  $A_1, A_2, A_3, \dots$  or  $B_1, B_2, B_3, \dots$  may be a constant carrier frequency  $f_T(t)$ , but it may also be a constant carrier frequency  $f_T(t)$  modulated by a modulation frequency.

The individual signal portions  $A_1, A_2, A_3, \dots$  of first signal portion sequence  $A(t)$  differ in their frequency or their carrier frequency  $f_T(t)$  in each case by a differential frequency  $f_{\text{Hub},A}/(N-1)$ ,  $f_{\text{Hub},A}$  being the difference between the carrier frequency of first signal portion  $A_1$  of first signal portion sequence  $A(t)$  and the carrier frequency of the  $N$ th signal portion of the first signal portion sequence  $A(t)$ , and  $N$  being the number of signal portions  $A_1, A_2, A_3, \dots$  of first signal portion sequence  $A(t)$ . The individual signal portions  $B_1, B_2, B_3, \dots$  of first signal portion sequence  $B(t)$  differ in their frequency or their carrier frequency  $f_T(t)$  in each case by a differential frequency  $f_{\text{Hub},B}/(N-1)$ ,  $f_{\text{Hub},B}$  being the difference between the carrier frequency of first signal portion  $B_1$  of second signal portion sequence  $B(t)$  and the carrier frequency of the  $N$ th signal portion of the second signal portion sequence  $B(t)$ , and  $N$  likewise being the number of signal portions  $B_1, B_2, B_3, \dots$  of first signal portion sequence  $B(t)$ . ~~Surprisingly, it proved to be especially advantageous~~ It may be provided to choose the differential frequency  $f_{\text{Hub},A}/(N-1)$  of the first signal portion sequence  $A(t)$  to differ from the differential frequency  $f_{\text{Hub},B}/(N-1)$  of the

second signal portion sequence B(t) ~~in particular~~, e.g., by at least 5%, advantageously e.g., by at least 10%.

5 Additionally, a frequency shift  $f_{\text{shift}}$  may be provided between signal portion A1 of first signal portion sequence A(t) and signal portion B1 of second signal portion sequence B(t).

Accordingly, first signal portion sequence A(t) results in

$$A(t) = \sum_{n=0}^{N-1} \cos \left( 2\pi \cdot \left( f_{TA1} + \frac{n}{N-1} \cdot f_{Hub,A} \right) \cdot t \right) \cdot \text{rect} \left( \frac{t}{T_{Burst}} - \frac{1}{2} - 2n \right)$$

10

and the second signal portion sequence B(t) in

$$B(t) = \sum_{n=0}^{N-1} \cos \left( 2\pi \cdot \left( f_{TA1} + f_{\text{shift}} + \frac{n}{N-1} \cdot f_{Hub,B} \right) \cdot t \right) \cdot \text{rect} \left( \frac{t}{T_{Burst}} - \frac{1}{2} - (2n+1) \right)$$

15 where  $f_{TA1}$  refers to the carrier frequency of signal portion A1 and rect refers to the rectangle function.

The transmission signal s(t) thus results in

$$s(t) = A(t) + B(t)$$

20

Via a coupler 32, transmission signal s(t) is supplied to a mixer 38 for mixing transmission signal s(t) and reflection signal r(t). Mixer 38 outputs an inphase signal I(t).

25 Via another coupler 33, transmission signal s(t) is additionally supplied to a phase shifter 37, which shifts the phase of transmission signal s(t) with respect to the carrier frequency by 90°, that is, by  $\pi/2$ . The phase-shifted transmission signal is supplied to a mixer 39 for mixing the  
30 phase-shifted transmission signal and the reflection signal r(t), which is supplied to mixer 39 via a coupler 34. Mixer 39 outputs a quadrature signal Q(t).

Inphase signal  $I(t)$  and quadrature signal  $Q(t)$  are mixed signals in the ~~sense of the claims~~ present context.

5 Radar device 30 has a multiplier 42, which is used to multiply quadrature signal  $Q(t)$  by the complex number  $j$  to yield  $jQ(t)$ .  $I(t)$  and  $jQ(t)$  are added to form a complex mixed signal  $m(t)$ . Complex mixed signal  $m(t)$  is ~~likewise~~ a mixed signal in the ~~sense of the claims~~ present context. Radar  
10 device 30 additionally has a frequency analyzer 43, which is used to form a spectrum  $M(\kappa)$  of complex mixed signal  $m(t)$  over frequency  $\kappa$ . Using a detector 44, the dominating frequency  $\kappa_A$  of mixed signal  $m(t)$  is ascertained with respect to first signal sequence  $A(t)$ , and the dominating frequency  $\kappa_B$  of mixed  
15 signal  $m(t)$  is ascertained with respect to second signal sequence  $B(t)$ .

~~In this instance, the~~ The processing of the individual signal sequences  $A(t)$  and  $B(t)$  ~~advantageously occurs~~ may occur  
20 separately by temporal separation such that with the aid of mixers 38 and 39 first signal portion sequence  $A(t)$  is mixed with a portion of first signal portion sequence  $A(t)$  (of reflection signal  $r(t)$ ) reflected by the at least one object 20 to form a first mixed signal  $I_A(t)$ ,  $Q_A(t)$  or  $m_A(t)$ , and  
25 second signal portion sequence  $B(t)$  is mixed with a portion of second signal portion sequence  $B(t)$  (of reflection signal  $r(t)$ ) reflected by the at least one object 20 to form a second mixed signal  $I_B(t)$ ,  $Q_B(t)$  or  $m_B(t)$ . For this purpose, frequency analyzer 43 forms a complex spectrum  $M_A(\kappa)$  of complex  
30 mixed signal  $m_A(t)$  over frequency  $\kappa$  and a complex spectrum  $M_B(\kappa)$  of complex mixed signal  $m_B(t)$  over frequency  $\kappa$ . Using detector 44, frequencies  $\kappa_A$  of complex mixed signal  $m_A(t)$  (that is, with respect to first signal sequence  $A(t)$ ) and the frequencies  $\kappa_B$  of complex mixed signal  $m_B(t)$  (that is, with  
35 respect to second signal sequence  $B(t)$ ) are ascertained.

Radar device 30 has an evaluator 45 for determining the distance R and/or the differential speed v. For this purpose, evaluator 45 solves the following system of equations:

5

$$\kappa_A = \frac{2v \cdot f_T}{c} \cdot (N-1) \cdot T_{Burst} - \frac{2R}{c} \cdot f_{Hub,A}$$

$$\kappa_B = \frac{2v \cdot f_T}{c} \cdot (N-1) \cdot T_{Burst} - \frac{2R}{c} \cdot f_{Hub,B}$$

where c is the speed of light.

- 10 In addition there may be a provision for detector 44 also to ascertain the difference  $\Delta\psi$  between the phase of complex mixed signal  $m_A(t)$  and the phase of complex mixed signal  $m_B(t)$ . ~~In this case~~ **For example** -- for determining distance R and/or speed difference v -- evaluator 45 may be used to solve the
- 15 following overdetermined system of equations, e.g. by a least square algorithm:

$$\Delta\psi = -2\pi \cdot \left( \frac{2v \cdot f_T \cdot T_{Burst}}{c} + \frac{2R \cdot f_{Shift}}{c} \right)$$

$$\kappa_A = \frac{2v \cdot f_T}{c} \cdot (N-1) \cdot T_{Burst} - \frac{2R}{c} \cdot f_{Hub,A}$$

$$\kappa_B = \frac{2v \cdot f_T}{c} \cdot (N-1) \cdot T_{Burst} - \frac{2R}{c} \cdot f_{Hub,B}$$

- There may be an additional provision to use more than two
- 20 signal portion sequences. Thus, for example, three signal portion sequences A(t), B(t) and C(t) of different differential frequency  $f_{Hub,A}/(N-1)$ ,  $f_{Hub,B}/(N-1)$  and  $f_{Hub,C}/(N-1)$  may be used and suitably emitted and processed. ~~In this case~~ **For example** -- for determining distance R and/or speed

difference v -- evaluator 45 may be used to solve, for example, the following overdetermined system of equations, for example, by a least square algorithm:

$$\kappa_A = \frac{2v \cdot f_T}{c} \cdot (N-1) \cdot T_{Burst} - \frac{2R}{c} \cdot f_{Hub,A}$$

5

$$\kappa_B = \frac{2v \cdot f_T}{c} \cdot (N-1) \cdot T_{Burst} - \frac{2R}{c} \cdot f_{Hub,B}$$

$$\kappa_C = \frac{2v \cdot f_T}{c} \cdot (N-1) \cdot T_{Burst} - \frac{2R}{c} \cdot f_{Hub,C}$$

$$10 \quad \Delta\psi_{AB} = -2\pi \cdot \left( \frac{2v \cdot f_T \cdot T_{Burst}}{c} + 2R \cdot \frac{f_{T,B} - f_{T,A}}{c} \right) \text{ where } f_{T,B} - f_{T,A} = f_{Shift,BA}$$

$$\Delta\psi_{AC} = -2\pi \cdot \left( \frac{2v \cdot f_T \cdot T_{Burst}}{c} + 2R \cdot \frac{f_{T,C} - f_{T,A}}{c} \right) \text{ where } f_{T,C} - f_{T,A} = f_{Shift,CA}$$

Accordingly there may be a provision to use, appropriately  
 15 emit and process, for example, four signal portion sequences A(t), B(t), C(t) and D(t) of different differential frequency  $f_{Hub,A}/(N-1)$ ,  $f_{Hub,B}/(N-1)$ ,  $f_{Hub,C}/(N-1)$  and  $f_{Hub,D}/(N-1)$ . ~~In this~~  
 ease **For example** -- for determining distance R and/or speed difference v -- evaluator 45 may be used to solve, for  
 20 example, the following overdetermined system of equations, for example, by a least square algorithm:



$$\kappa_A = \frac{2v \cdot f_T}{c} \cdot (N-1) \cdot T_{Burst} - \frac{2R}{c} \cdot f_{Hub,A}$$

$$\kappa_B = \frac{2v \cdot f_T}{c} \cdot (N-1) \cdot T_{Burst} - \frac{2R}{c} \cdot f_{Hub,B}$$

$$\kappa_C = \frac{2v \cdot f_T}{c} \cdot (N-1) \cdot T_{Burst} - \frac{2R}{c} \cdot f_{Hub,C}$$

$$\kappa_D = \frac{2v \cdot f_T}{c} \cdot (N-1) \cdot T_{Burst} - \frac{2R}{c} \cdot f_{Hub,D}$$

$\Delta\psi_{AB}$  = see above

5  $\Delta\psi_{AC}$  = see above

$$\Delta\psi_{AD} = -2\pi \cdot \left( \frac{2v \cdot f_T \cdot T_{Burst}}{c} + 2R \cdot \frac{f_{T,D} - f_{T,A}}{c} \right) \text{ where } f_{T,D} - f_{T,A} = f_{Shift,DA}$$

In addition, a different time duration may be provided for the signal portions of different signal sequences.

10

Fig. 5 ~~shows~~ **illustrates** an exemplary embodiment for an optical measuring device 50 for the improved measurement of speed difference  $v$  or distance  $R$ . Optical measuring device 50 has an optical sensor 60 and an evaluation device 61, which  
 15 corresponds essentially to evaluation device 41. Optical measuring device 50 has an oscillator or a signal generator 51 for producing a transmission signal  $s_1(t)$ , a laser 55 for emitting light at the frequency of transmission signal  $s_1(t)$  and a photoelement 56 for receiving a light reflected by at  
 20 least one object such as obstacle 20 and for producing a reflection signal  $r_1(t)$  at a frequency corresponding to the frequency of the reflected light. The transmission signal  $s_1(t)$  produced by signal generator 51 corresponds to

transmission signal  $s(t)$ , but is located in another frequency range. Via a coupler 52, transmission signal  $s_1(t)$  is supplied to a mixer 58 for mixing transmission signal  $s_1(t)$  and reflection signal  $r_1(t)$ . Mixer 58 outputs an inphase  
5 signal  $I(t)$ .

Via another coupler 53, transmission signal  $s_1(t)$  is additionally supplied to a phase shifter 57, which shifts the phase of transmission signal  $s_1(t)$  with respect to the carrier  
10 frequency by  $90^\circ$ , that is, by  $\pi/2$ . The phase-shifted transmission signal is supplied to a mixer 59 for mixing the phase-shifted transmission signal and the reflection signal  $r_1(t)$ , which is supplied to mixer 59 via a coupler 54. Mixer 59 outputs a quadrature signal  $Q(t)$ .

15 The elements, signals and frequency ranges in the ~~figures~~ **Figures** are drawn with simplicity and clarity in mind and not necessarily to exact scale. Thus, for example, the orders of magnitude of some elements, signals or frequency ranges are  
20 exaggerated in order to facilitate understanding ~~of the exemplary embodiments of the present invention.~~

~~List of Reference Symbols:~~

**LIST OF REFERENCE CHARACTERS**

	1	motor vehicle
	2, 3	bumper
5	4, 5	side mirror
	6, 7	side door
	8	hatchback
	10, 14, 15, 16	distance and/or speed sensor
	20	object or obstacle
10	30	radar device
	51	signal generator
	33, 34, 52,	
	53, 54	coupler
	35	transmitting antenna
15	36	receiving antenna
	57	phase shifter
	39, 58, 89	mixer
	40	radar device
	41, 61	evaluation device
20	42	multiplier
	43	frequency analyzer
	44	detector
	45	evaluator
	50	optical measuring device
25	55	laser
	56	photoelement
	60	optical sensor
	A, B	signal sequence
	A1, A2, A3, B1,	
30	B2, B3	signal portion
	$f_{Hub,A}$ , $f_{Hub,B}$	difference between the carrier frequency of the first signal portion of a signal portion sequence and the carrier frequency of the last signal portion of the signal portion sequence
35		

	$f_{\text{shift}}$	frequency shift
	$f_T(t)$	carrier frequency
	$I(t)$	inphase signal
	$m(t)$	complex mixed signal
5	$M(\kappa)$	complex spectrum
	$Q(t)$	quadrature signal
	$R$	distance
	$r(t), r_l(t)$	reflection signal
	$s(t), s_l(t)$	transmission signal
10	$t$	time
	$T_{\text{Burst}}$	time duration
	$v$	speed difference
	$v_F$	speed of the motor vehicle
	$v_H$	speed of the obstacle
15	$\Delta\psi$	difference in the phase of two mixed signals
	$\kappa$	frequency
	$\kappa_A, \kappa_B$	measured frequency of a complex mixed signal

# ABSTRACT

A measuring device , e.g., a measuring device for a motor vehicle, is for measuring a distance between the measuring device and at least one object and/or measuring a difference  
5 in speed between the measuring device and the at least one object. The measuring device includes an emitting apparatus for transmitting a transmission signal encompassing at least two sequences of signal portions, a first sequence of signal  
10 portions and a second sequence of signal portions with two respective temporally alternating signal portions. The frequency of at least two signal portions of a sequence of  
signal portions differs by one respective difference frequency, the difference frequency of the first sequence of  
15 signal portions being different from the difference frequency of the second sequence of signal portions.